On the Improvement of Energy Efficiency of the Organic Hydride System,

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Introduction

Hydrogen has been recognized as the ultimate clean fuel because when consumed it delivers superior energy performances and produced zero emissions besides water vapor. However, its large scale utilization is typically hampered by insufficient storage capabilities. Many research attempts have been made to develop technologies for hydrogen storage that simultaneously satisfy energy efficiency, cost, as well as compactness in terms of both volume and weight. The organic hydrides are liquid so that the transportation and storage are very easy because they can be handled in almost the same way as gasoline with keen contrast against molecular hydrogen. Molecular hydrogen, liquefied or compressed, needs costly infrastructure apparatus for being used in high pressures or low temperatures.

As an organic hydride, MCH/TL system has been a common choice[1)] because of low toxicity, high stability, low cost, or availability as an industrially manufactured material. However, the most important is, we believe, energetic properties such as energy efficiency or density. So, we tried to make considerations on this issue on the basis of thermodynamic and electrochemical calculations.

Theoretical Calculation

All of thermodynamic and electrochemical calculations in this study were made by using HSC Chemistry 5.1(Outokumpu Research Oy, Finland) or when we need to make calculations which are not available, we extracted parameters of each compound from the listing in the software. Then, thermodynamic parameters such as Cp, ΔH, K, and equilibrium compositions could be exactly duplicated on excel.

Organic Hydride System

Fig. 1 shows an overview of organic hydride system, where two parallel methods are described. One is a conventional method that MCH is dehydrogenated to TL to yield hydrogen, the hydrogen is used in fuel cell(FC) to generate electricity and TL is returned to re-hydrogenated to complete the cycle. The weakest point of this method is the energy efficiency because the de-hydrogenating reaction is endothermic that requires higher temperatures than 300C. We are proposing another method to overcome the difficulty, where the dehydro-genation reaction is coupled with the FC and the whole reaction was turned into exothermic.

We are proposing an idea that a direct organic hydride FC[2)], where oxy-dehydrogenation reactions are employed(Fig. 2). Fig. 3 shows the e.m.f. voltages for some of organic hydride candidates. It is noteworthy that many compounds could be used in the FC system and their theoretical voltages are more than 1V, sufficient to be considered for a practically usable system. Therefore, the species used as energy carrier should be determined by taking into account of other factors, such as environmental influences and total cost performance.

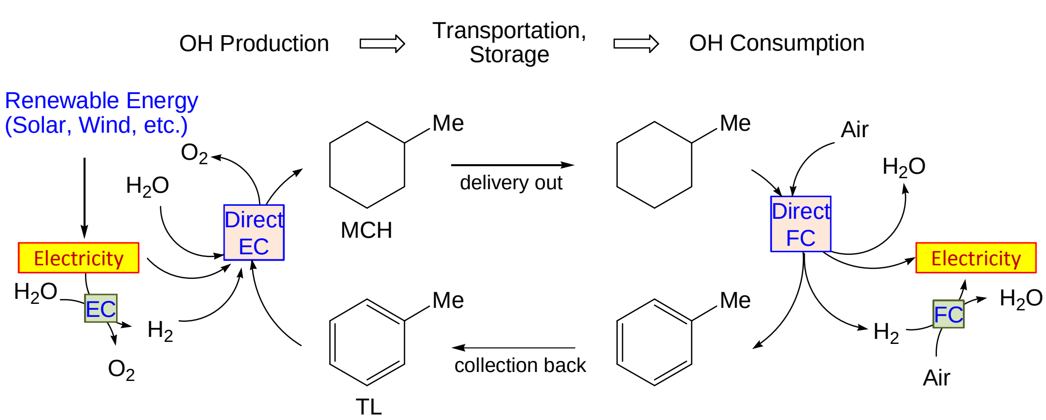

Fig.1 Organic Hydride System as the Carrier of Renewable Energies
(OH: Organic Hydride, EC: Electrolysis Cell, FC: Fuel Cell)

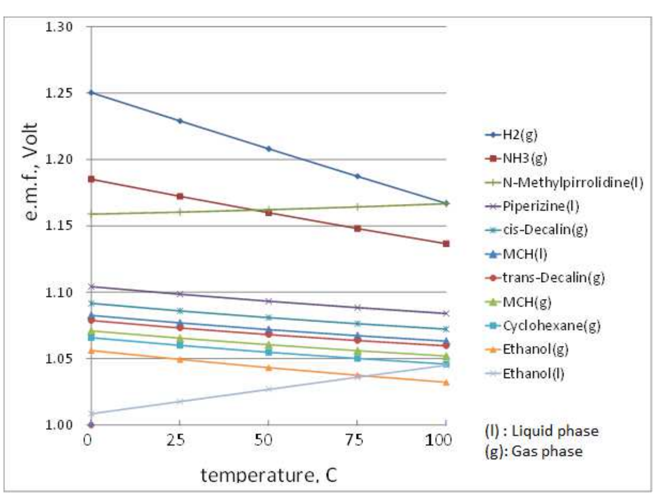

Fig.3, Temperature Dependences of e.m.f. for Organic Hydride Candidates

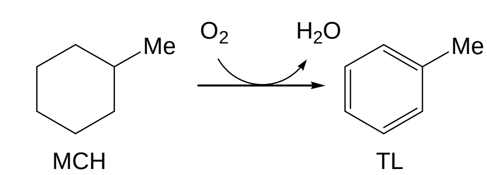

Fig.2 Oxy-dehydrogenation reaction of MCH(methylcyclohexane)

References

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2) N.Kariya, A.Fukuoka,M.Ichikawa, Phys. Chem. Chem. Phys., **8**, 1724(2006).